Columbia Forest District (Golden TSA, Revelstoke TSA, TFL 55, and TFL 56)

Vegetation Resources Inventory Strategic Plan

MINISTRY OF FORESTS
RESOURCES INVENTORY BRANCH
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Executive Summary

This Vegetation Resources Inventory (VRI) Strategic Inventory Plan (SIP) outlines the inventory activities and products needed to address the forest management issues identified by stakeholders in the Columbia Forest District. The VRI SIP (VSIP) provides a general strategic direction for implementing the provincial VRI and management inventory activities in the Columbia Forest District. It is based on a meeting held in September 1997 at the Columbia Forest District office and a consultant's report entitled *Columbia Forest District Vegetation Resources inventory Ground Sampling Plan*. Due to recent improvements in the understanding of the sample statistics associated with the VRI, specific sample size estimates and issue management summaries may not be consistent between this VSIP and the original *ground-sampling plan*.

The objective of the VSIP is to provide a technical foundation that will enable stakeholders to prepare coordinated multi-year VRI Project Implementation Plans (VPIPs) for submission to Forest Renewal BC (FRBC) or other appropriate agency for funding support. A VPIP is a working document that details the specific operational activities associated with implementing each of the inventory activities identified in the VSIP. The VPIP identifies the geographic-areas scheduling, priorities, plot location coordination, inventory costs year by year, and roles and responsibilities for implementation.

The *provincial VRI* provides baseline spatial and non-spatial databases for the entire Forest District. It involves photo-interpretation to the new VRI standards with ground sampling to adjust the initial estimates. The provincial VRI ground sampling would provide a basis for calculating unbiased overall averages and totals for timber and non-timber vegetation resources for the entire landbase in the District.

The *management VRIs* are specialized inventories that provide the detailed information required for specific resource management, i.e., day-to-day forest management. One or more VRI sampling procedures(photo interpretation, ground sampling, NVAF) may be used for management inventories. Management inventories may focus on specific resource types (timber, range, ecology), geographic areas (e.g., landscape unit, TFL), attribute sets (e.g., Douglas-fir leading stands, age class 4+).

The stakeholders in the Columbia Forest District identified the following VRI activities and products:

a) Improve the photo interpreted inventory in Golden TSA, Revelstoke TSA, and the National Parks. *Note that a complete VRI photo-interpretation project is currently underway in the Golden TSA.*

b) Implement provincial VRI ground sampling in the District. This information will provide support for provincial inventory reporting, timber supply analysis, the implementation of the biodiversity guidelines, growth and yield monitoring initiatives and help improve overall net merchantable volume estimates. This sampling will aim to achieve a sampling error of ±10% for net timber volume in the treed portion of the district landbase.

c) Conduct a rare plant species inventory and improve biodiversity assessment (i.e., plant lists) in the District.

The identified VRI activities in the District include new photo-interpretation, retrofit photo-interpretation, and ground sampling. New photo interpretation projects will be initiated in those areas where the existing inventory is not adequate for a retrofit. For the photo-interpreted estimates retrofitted inventory, the existing polygon timber inventory should be translated to VRI format, and additional VRI (non-timber) attributes should be added through photo-estimation of the existing photos. Ground sampling should be conducted over the entire District to support the provincial VRI and the identified management inventories. The sample sizes for the ground sampling are listed below (Table 1).

Table 1. Summary of the recommended Columbia Forest District Inventory Initiatives.

Land Type	Number of sample clusters – All VRI measurements	Number of sample clusters – Tree measurements only	Total
Photo-Interpretation Activities			
New photo interpretation for Golden TSA	N/A	N/A	920,000 ha
Retrofit photo interpretation for Revelstoke TSA	N/A	N/A	500,000 ha
New photo interpretation for National Parks	N/A	N/A	425,000 ha
Ground Sampling Activities			
Provincial VRI			
Vegetated Treed	60	60	120
Remaining Area (Non-Vegetated; Vegetated Non-Treed	*70*		*70*
NVAF sampling WPV sampling			*85 trees* *10 polygons*
Management Inventories			
Rare Species Inventory	Not defined		
Total	130	60	

The next step is for the stakeholders to prepare coordinated VPIPs. MOF Regional and Branch staff will provide assistance as required. The stakeholders will develop criteria for setting priorities among the activities and products. Funding for the inventory activities is not discussed in this VSIP; however, the final VSIP and VPIPs should be considered in submissions by the Region to FRBC or other coordinating agency for funding.

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1. Introduction

1.1 Overview

This Vegetation Resources Inventory (VRI) Strategic Inventory Plan (SIP) outlines the inventory activities and products needed to address the forest management issues identified by stakeholders in the Columbia Forest District. The Ministry of Forests (MOF) Resources Inventory Branch prepared this VRI SIP (VSIP) following consultative meetings involving key forest inventory stakeholders and in consideration of relevant documentation. The VSIP provides a general strategic direction for implementing the provincial VRI and management inventory activities in the Columbia Forest District.

1.2 VRI Procedures and Products

The VRI is a vegetation inventory process for assessing the quantity and quality of BC's timber and other vegetation resources. The VRI addresses the inventory design-related issues raised by the Forest Resources Commission in its 1991 report *The Future of Our Forests*. The VRI was designed by inventory specialists from government, industry, and academia, and has been approved by the BC Resources Inventory Committee (RIC). The RIC objectives are to develop a common set of standards and procedures for provincial resources inventories.

The VRI process consists of procedures for:

1. *Photo-Interpreted Estimates*
   - Delineating and classifying vegetated polygons using the BC Landcover Classification Scheme (BCLCS).
   - Making initial estimates of the vegetation attributes within polygons.

2. *Ground Sampling*
   - Sample planning.
   - Locating and establishing sample plots.
   - Collecting data related to trees; site, soils, plants, and succession; coarse woody debris; and range resources.
   - Net Volume Adjustment Factor (NVAF) sampling.
   - Within Polygon Variation (WPV) sampling.

These VRI procedures and other terms in this report are defined further in the Glossary (Appendix A).

The VRI procedures provide spatial and non-spatial products for resource-specific management interpretations, provincial inventory reporting, monitoring, and research. The management interpretations include timber management, ecosystem management, and habitat management. The spatial products include:

- Line work – polygon boundaries.
- Vegetation Inventory File Database – adjusted and unadjusted polygon labels and estimates.

The non-spatial products include:

- Raw Database – Raw data from field cards.
- Summary Database – Compiled data and inventory statistics.
- NVAF Database – NVAF stem analysis data (raw, compiled, and statistics).
- WPV Database – WPV polygon data (raw, compiled, and statistics).

1.3 VRI Overriding Principles

The new VRI procedures are now being implemented throughout the province. The implementation is based on the following guiding principles:

- To integrate the provincial inventory activities, including the provincial VRI, management inventories, and the National Forest Inventory.
- To implement inventory projects to satisfy business needs as defined in the VSIP and VPIP documents. The VSIP identifies the forest management issues in a District, and the VRI activities and products required to address those issues. The VPIPs identify the priorities and spatial location of VRI activities (Section 2).
- To develop spatial VRI products in a structured way (e.g., implement the photo interpretation activities in blocks such as mapsheets or watersheds, and estimate all the attributes listed in the photo interpretation manual).
- To implement inventory projects following approved VRI implementation standards as defined in the MOF Resources Inventory Branch 1998 report *Vegetation Resources Inventory Implementation Strategy to Integrate Management, Provincial, and National Inventories*.

Implementing the identified inventories using VRI standards will address the issues raised by the Forest Resources Commission's 1991 report *The Future of Our Forests*. The issues raised relate to the inadequacy of forest inventories in the province, and included lack of statements of precision on the inventory, inadequate information on non-timber vegetation, and the narrow focus on commercial timber volume and the operable landbase.

1.4 Document Objectives

This VSIP is for the implementation of the provincial VRI and management inventories in the Columbia Forest District in the Nelson Forest Region. It was developed through consultation with various stakeholders in the Columbia Forest District, including the MOF (Branch, Region, and District staff), Parks Canada, Evans Forest Products and the Revelstoke Community Forest Corporation, who identified inventory needs and priorities. Appendix C lists the individuals attending each of the meetings and conference calls held to discuss this plan.

This VSIP:

- defines the strategy for the provincial VRI in Columbia Forest District;
- defines the management inventory products;
- identifies the inventory activities required to produce the desired inventory products; and
- outlines a proposed implementation strategy.

2. INVENTORY PLANNING

2.1 Planning Process

The VRI planning process involves developing strategic plans (VSIPs) and project plans (VPIPs) that identify resource-specific management issues, desired inventory products, and priorities. A VSIP outlines the VRI products needed to address the identified forest management issues, and provides a general strategic direction for implementing the provincial VRI and management inventory activities in the District.

The stakeholders in the District can use the completed VSIP to prepare coordinated VRI Project Implementation Plans (VPIPs). The VPIPs are working documents that detail the specific operational activities associated with implementing and documenting the inventory activities identified in the VSIP. A VPIP can describe ground-sampling or photo-interpretation projects, and identifies the project geographic areas, priorities, plot location coordination, inventory costs by year, and roles and responsibilities for implementation.

The VSIP and VPIPs provide the framework for coordinating the implementation of the provincial VRI over the District, and management inventories over priority areas. The VSIP and VPIPs seek to ensure that VRI products address important issues in priority areas, and support resource-specific management interpretations that address forest management issues. This planning process defines the baseline inventory product needs, ensures that the right baseline products are selected to meet a range of applications, and achieves efficiencies in the delivery of the desired inventory products. Coordinated inventory planning also maximizes the value of the inventory data produced in issue areas by ensuring that the VRI products are useful for addressing more than one resource issue.

2.2 Funding

Funding for these inventory activities, or follow-up resource-specific management interpretations, is not discussed in the VSIP since funding mechanisms may vary from time to time. The stakeholders, lead by the District, develop criteria for setting priorities among the VRI activities and products identified in the VSIP. The VSIP and VPIPs should be considered in submissions by the Region to Forest Renewal BC (FRBC) or other coordinating agency for funding.

3. BUSINESS CONSIDERATIONS

3.1 Forest Management Issues

Forest management issues were identified during the recent timber supply review (Table 2). An assessment of potential impacts of the VRI ground sampling on these management issues is also shown in this table.

Table 2. Forest management issues for the Columbia TSA and potential impacts for the VRI.

	Issue[1]	Remarks
	Golden TSA	
1.	Inventory audit: mature volumes were overestimated.	Ground-sampling data will check the inventory audit results.
2.	Decay, waste, and breakage: assess factors through destructive testing.	VRI NVAF sampling methods will be used to monitor (check) taper and loss factors. Note: Destructive sampling/analysis for C&H in the ICH vk, wk, mk, mw has been completed; taper and loss factor adjustments have been determined.
3.	Increase land base: assess feasibility of non-conventional technology.	Application of the inventory.
4.	20-year timber availability study: complete by January 1997.	Application of the inventory.
5.	Harvesting on steep slopes: review prior to next analysis.	Application of the inventory.
6.	Regeneration: evaluate the ability to conduct high elevation regeneration.	Application of the inventory.
	Issue	Remarks

[1] BC Ministry of Forests, Timber Supply Branch. 1996. Forest Management Issues Identified Through the AAC Determination Process, TSA/TFL Timber Supply Reviews: 1992-1996. 31 December 1996. Victoria BC. Pages 91-92; 103-104

	Issue	Remarks
	Revelstoke TSA	
1.	Caribou habitat: appropriate allowances should be made for harvesting.	Application of the Inventory
2.	Site productivity: assess results of paired plot study.	Site index measurements from ground sampling plots can be used to help check the site index estimates in the current inventory database, and to develop correlations with other attributes. However, these data will not address the issue of potential site index and productivity of stands and will not correct for inappropriate site curves.
3.	Integrative resource management objectives should be studied further.	Application of the Inventory
4.	Mature volumes overestimated: review actual versus expected volumes; further study of inventory volumes is required.	Audit does not show this to be a serious concern
5.	Intensive silviculture: assess effects on regenerated stands.	Application of the inventory.
6.	Unsalvaged losses: quantify for next analysis.	Application of the inventory.
7.	Riparian habitat: determine impacts.	Application of the inventory.
	TFL 55	
1.	Riparian areas: undertake more comprehensive riparian mapping.	Has been addressed by the TFL.
2.	Inventory audit: completed.	The inventory audit indicated an average audit volume of 402 m^3/ha, which was compared to the average inventory volume of 414 m^3/ha. The difference of 12m^3/ha was not considered statistically significant.
3.	ESAs – soils: soil mapping and geo-technical analysis required for next analysis.	Application of the inventory.
4.	Operability: revise operability map to reflect current technology and market conditions.	Application of the inventory.
5.	Regeneration delay: monitor regeneration delay periods.	Application of the inventory.
6.	Low site: review performance in low site areas.	Possible unit for a problem forest type study.
7.	Unsalvaged losses: monitor actual losses to fire, insects, and disease.	Application of the inventory.
8.	Silviculture treatments: more intensive treatments may be required on steep terrain and brush-prone sites.	Application of the inventory.
9.	Caribou habitat: incorporate caribou management options approved as part of West Kootenay-Boundary LUP.	Application of the Inventory

	Issue	Remarks
	TFL 56	
1.	ESAs – soils: soil mapping and geotechnical analysis required for next analysis.	Geotechnical analysis and TSLD level mapping was completed in 1995.
2.	Riparian: undertake more comprehensive riparian mapping.	Has been addressed by the TFL.
3.	Inventory audit completed.	The inventory audit indicated an average audit volume of 422 m^3/ha, which was compared to the average inventory volume of 439 m^3/ha. The difference of 17m^3/ha was not considered statistically significant.
4.	Operability: revise operability map to reflect current technology and market conditions.	Application of the Inventory.
5.	Low site: review performance in low site areas.	Possible unit for a problem forest type study.
6.	Unsalvaged losses: monitor actual losses to fire, insects, and disease.	Application of the inventory.
7.	Regeneration delay: monitor regeneration delay periods.	Application of the inventory.
8.	Silviculture treatments: more intensive treatments may be required on steep terrain and brush-prone sites.	Application of the Inventory.
9.	Caribou habitat: incorporate caribou management options approved as part of West Kootenay-Boundary LUP.	Application of the Inventory.

3.2 Inventory Issues

The following is a summary of inventory issues derived from the forest management issues in the District:

- Decay and waste estimates in Cedar/Hemlock, ICH, and B in ESSF (*projects are in progress*).
- Site index in older stands.
- Medicinal plants (First Nations).
- Riparian habitat (ensure a proportional number of samples fall in riparian areas).
- Parks – old growth attributes (age class, structural attributes, lichen production).
- Parks – habitat mapping (Photo interpretation can assist).
- Parks – rare species inventory.
- Monitoring indicators of sustainable forest management – decay monitoring and provincial monitoring.

- Provincial and district monitoring of the indicators of sustainable forest management, as defined by the Canadian Council of Forest Ministers (CCFM).[2] Monitoring would involve measuring changes and trends in some of these indicators, which include percent and extent of area by forest type and age class, and mean annual increment by forest type and age class.
- Issues raised by the Forest Resources Commission's 1991 report *The Future of Our Forests* regarding the inadequacy of forest inventories in the province. These concerns included lack of statements of precision on the inventory, inadequate information on non-timber vegetation, and the narrow focus on commercial timber volume and the operable landbase.

3.3 VRI Activities and Products

The forest management issues identified in Table 2, suggest that the following VRI activities and products are needed:

a) Improve the photo interpreted inventory in Golden TSA, Revelstoke TSA, and the National Parks. A *complete VRI photo-interpretation project is currently underway in the Golden TSA.*

b) Implement VRI ground sampling in the District. This information will provide support for provincial inventory reporting, timber supply analysis, growth and yield monitoring initiatives, and help improve overall net merchantable estimates. This sampling will aim to achieve a sampling error of ±10% for net timber volume in the treed portion of the district.

c) Conduct a rare plant species inventory in the District.

4. INVENTORY PLAN

4.1 Overview

This section outlines the inventory activities needed to develop specific VRI products. The VRI activities include photo-interpreted estimates and ground sampling. The ground sampling may be at the District level (provincial VRI) or sub-unit level (management inventories):

- *Provincial VRI* involves ground sampling to provide a ground sample plot database for all attributes over an entire Forest District. The ground sample plot data are combined (through statistical analysis) with the photo-interpreted estimates to provide a spatial database at the District level.

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[2] Canadian Council of Forest Ministers. 1995. Defining sustainable forest management. A Canadian approach to criteria and indicators. Natural Resources Canada. Canadian Forest Service. Ottawa, Ontario. 22 pages.

- *Management (sub-unit) Inventories* involve ground sampling using selected components of the VRI procedures, to produce VRI databases to address one or more resource-specific management issues (timber, ecosystem, habitat, etc.). The ground sample plot data are combined (through statistical analysis) with the photo-interpreted estimates to provide a spatial database at the sub-unit level. Management inventories are coordinated as much as possible to produce VRI products with multiple resource applications.

The VRI baseline products can be used in further analyses, sometimes in conjunction with data from additional sources, to produce Resource-Specific Information (RSI) needed to address forest management issues. RSI may include information for timber supply review, habitat management, and ecosystem management to address resource-specific management issues. The VRI-based products are used in VRI ecosystem and habitat mapping. The VRI-EM is an ecosystem map consisting of VRI polygons with estimated site series labels in the same format as Terrestrial Ecosystem Mapping (ecosystem, modifiers, and structural stage). The VRI-HM products are habitat maps for species at risk, ungulates, or species of management concern, such as grizzly bear.

4.2 Photo-Interpreted Estimates Inventory

4.2.1 Objective

The objective of this initiative is to improve the photo interpreted inventory in the Columbia Forest District. It may require complete new photo interpretation for all attributes or just the acquisition of the newer attributes required in the VRI. The product is a spatial database consisting of unadjusted photo-interpreted estimates. Ground sampling to check and adjust the photo-interpreted estimates is discussed as a separate process (See section Provincial Ground Sampling 4.3.1).

4.2.2 Target Area

The stakeholders identified several areas requiring improvement; the Golden TSA requires a complete new photo-interpreted inventory; the Revelstoke TSA requires a retrofitted photo interpreted inventory; the National Parks require a complete new photo-interpreted inventory.
A complete VRI photo-interpretation project is currently underway in the Golden TSA.

4.2.3 Options

The following two options for the photo-interpreted estimates inventory are possible:
Option 1 -Retrofit

The retrofit process aims to incorporate the new standards for VRI delineation and estimation into the existing inventory. The process involves limited photo estimation and delineation using the existing document photos for the area. The assumption is that the current inventory is good and the goal is to fill in the gaps between the old and new standards. The intent is to convert the existing database to a full VRI database by

collecting the required additional data. (There are opportunities to include additional features in the retrofit process depending on business needs).

Option 2 - New Photo Estimation

New photo estimation is used to incorporate the new standards for VRI delineation and estimation into an area. It involves the completion of new delineation and polygon estimates for the entire landbase, using the most current photography. It should be used in those cases where a VPIP indicates that there is a serious problem with the existing inventory. New photo interpretation may also be applicable in TSAs that have not had a traditional re-inventory in the last 10 years. These inventories are typically 25-35 years old and were not delineated or classified to current standards.

4.2.4 Implementation

A VPIP should be developed for all future photo-interpretation activities in the Columbia Forest District. The plan should follow the guidelines outlined in the MOF document *Vegetation Resources Inventory Guidelines for Preparing a Project Implementation Plan for Photo Interpretation.* Preparing a VPIP will involve identifying what needs to be improved (attributes or delineation), where, and how.

The photo-interpreted inventory will be implemented on a multi-year basis, as follows:[3]

1. Define target population and objectives.
2. Assemble existing information, including pre-inventory assessment (PIA) documents, TRIM bases, photos, and updated overlays.
3. Prepare work plan.
4. Seek contractor to do the work.

Then on a yearly basis:

5. Delineation and Data Source Transfer (April to June)
6. Conduct fieldwork (July to September).
7. Conduct the photo-interpretation (September to January).
8. Digitize, check plots, and complete final quality assurance (September to April).
9. Prepare photo-interpreted estimates database and project report.

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[3] *Photo-Interpretation (Phase I) Project Management Guidelines.* May 1997. Ministry of Forests. Resources Inventory Branch. Victoria, BC. (Contact: Bob Krahn).

4.3 Provincial VRI Ground Sampling

4.3.1 Overview

The provincial VRI provides baseline spatial and non-spatial databases for the entire Forest District. The provincial VRI ground sampling activities include ground sampling, Net Volume Adjustment Factor (NVAF) sampling, and Within Polygon Variation (WPV) sampling.

When implemented, the provincial VRI ground sampling would provide:

1. A basis for calculating unbiased overall averages and totals for timber and non-timber vegetation resources for the entire landbase in the District. Provision of this information addresses the concerns expressed by the Forest Resources Commission in its 1991 report *The Future of Our Forests*.
2. The initial conditions and locations for measuring changes and trends in the indicators of sustainable forest management, at the provincial or District level.[4] The changes and trends can be used to provide a province-wide statement of sustainability of our forest practices that would be based on an inventory with a statistically valid approach. This monitoring information can be used to counter misinformation about BC's forestry practices, to protect BC forest products markets, and to address public environmental concerns. This information was not available in previous provincial inventories, as there was no valid monitoring protocol.
3. Baseline VRI data to develop ecosystem and habitat mapping to address ecosystem and habitat management issues in forest land management.
4. Baseline data to confirm district biodiversity guidelines, non-forest classification, and site index-BEC correlations.
5. Additional information for non-timber resources (e.g., plant lists) by indicating where more intensive sampling could improve estimates for specific plants (e.g., medicinal plants) and other botanical products.
6. The VRI plot locations that can be used to measure a variety of other resources (e.g., range), for special projects, and for management inventories. The plot locations are established in an unbiased way and are re-locatable to allow re-visits.

4.3.2 Landbase

The total area of the Columbia Forest District is approximately 2 million ha (Table 3) and includes the Golden and Revelstoke TSAs, TFL 23[5], TFL 55, TFL 56, and National and Provincial Parks.

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[4] Criteria and indicators of sustainable forest management were defined by the Canadian Council of Forest Ministers (CCFM) in their 1995 report *Defining Sustainable Forest Management. A Canadian Approach to Criteria and Indicators* (Natural Resources Canada. Canadian Forest Service. Ottawa. Ontario. 22 pages).

[5] TFL 23 will be addressed in the Arrow VRI VSIP

Table 3. Columbia Forest District, including the TSAs, TFLs, and Parks.

Land Type	Area (ha)	Area (%)	THLB (%)[6]
Golden TSA	921,231	43	19
Revelstoke TSA	504,000	23	12
TFL 23	70,000	3	37
TFL 55	92,227	4	22
TFL 56	119,505	6	20
Parks	453,617	21	
Hamber Provincial Park	24,625		
Glacier National Park	135,132		
Kootenay National Park	138,620		
Mount Revelstoke National Park	26,138		
Yoho National Park	129,102		
Total	2,160,580		

4.3.3 Photo-Interpreted Estimates

Implementing provincial VRI ground sampling in the Columbia Forest District requires use of the spatial database described in Section 4.2. The spatial database used will be either the existing timber information rolled into the VRI format or a new photo estimated or retrofitted inventory database.

4.3.4 Ground Sampling

Ground Sampling provides the statistical rigor for estimating overall totals and averages for timber and non-timber vegetation resources (e.g., medicinal plants and other botanical forest products) in the District. The total number of VRI sample clusters will aim to achieve a sampling error of ±10% (95% probability) for net timber volume in the vegetated treed portion of the District and allow for calculation of sampling errors for other VRI attributes. Information will be collected on all attributes, but the variability of net volume will be used to set the sample size for the VRI.

The number of samples required to achieve the sampling error standard is a function of the variation of net volume within the inventory unit, estimated by the coefficient of variation (CV%). The CV used to estimate the total number of plots to achieve a sampling error of ±10% for net volume was assumed to be 55%.[7] To achieve the VRI standard at a reasonable cost, two types of VRI plots should be used:

- Full VRI sample clusters, where the full suite of information (timber, coarse woody debris, range, and ecology) is collected.
- Timber emphasis VRI plots (TEPs), where only tree information is collected.

[6] Timber harvesting landbase based on recent timber supply reviews.

[7] This CV was estimated from the Inventory Audit data.

The sample sizes required to implement the ground-sampling phase of the provincial VRI is summarized in Table 4.

Table 4. Estimated sample size required to implement the ground-sampling phase of the provincial VRI in the Columbia Forest District.

Land Type	Number of sample clusters – All VRI measurements	Number of sample clusters – TEP	Total number of sample clusters
Provincial VRI			
Vegetated Treed	60	60	120
Remaining Area (Non-Vegetated; Vegetated Non-Treed	*70*		*70*
Total	*130*	*60*	*190*
NVAF sampling			*85 trees*
WPV sampling			*10 polygons*

A sampling error standard is necessary to provide a basis for determining sample size in inventories. In the VRI, the allowable sampling error standard is set at ±10% for net volume at the District level; however, this standard does not apply to other attributes in the inventory.

The total number of full VRI samples (60) will be adequate to achieve a sampling error of ±15% in the vegetated treed landbase. Timber emphasis VRI plots (60) are then used to reduce the sampling error in the vegetated treed landbase to the desired ±10% . In the remaining area (non-treed and non-vegetated) of the unit, the number of full VRI samples established (70) will be the ratio of the remaining area to the vegetated treed area, multiplied by the number of VRI samples required to achieve a sampling error of ±15% in the vegetated treed landbase.

Implementing the two types of samples (full VRI and TEPs) minimizes the number of full VRI plots required, and will result in savings of time and money.

4.3.5 NVAF and WPV Sampling

NVAF and WPV sampling is required to complete the provincial VRI. The existing tree volume loss factors and individual tree taper models may be in error. NVAF sampling provides factors to adjust net tree volume, which is estimated from net factoring and taper equations. The adjustment accounts for hidden decay and possible taper equation bias. NVAF sampling involves detailed stem analysis of sample trees, calculation of actual net volume, and calculation of the ratio between actual net volume and estimated net volume.

NVAF is recommended for management unit inventories if they are completed prior to the District NVAF. NVAF sampling efforts may be combined between District and management unit inventories. If NVAF sampling is not completed, the existing loss factors may be used.

The WPV sampling provides information to estimate the individual polygon error, assessed as the difference between the adjusted polygon value and the "true" value for that polygon based on intensive sampling of sample polygons.

As shown in Table 4, a total of 85 sample trees (75 live, 10 dead) are required for NVAF sampling (selected from 15 treed polygons and 1 non-treed polygon). At least 10 sample polygons, each with 20-50 full measure and count plots, are required for WPV sampling.

4.3.6 Statistical Analysis

Statistical analysis is the process of adjusting the the photo-interpreted estimates using the ground sampling observations. The purpose of the analysis is to obtain overall averages and totals for the District that are statistically unbiased, and to adjust the existing or new photo-interpreted estimates database to obtain individual polygon values.

Statistical analysis includes two steps:

1. Statistical estimation of overall District values. These values include totals and averages for continuous attributes, and error matrices for categorical variables.
2. Statistical adjustment, which is the process of assigning values to individual polygons such that their total (or error matrix) for the District matches that obtained in Step 1.

4.3.7 Implementation

To achieve the provincial VRI objectives, the sampling could be implemented over the entire District in a two-step process. This process would be done as follows: step 1 is to install approximately 60 sample clusters, over the entire District, in the first field season; step 2 is to install the remaining sample clusters in the second field season.

Sampling in the first year will provide experience to refine the process for the second field season, and information to precisely calculate the remaining number of samples required to meet the precision target of ±10% for net volume in the treed portion of the District.

An estimated total of 190 sample clusters will be assumed for planning, training, and other logistic considerations. Matching unavailable sites and sub-sampling of sample clusters with difficult access should be anticipated and planned for, as these activities will increase inventory costs.

The implementation process could proceed as follows:

1. Select the Provincial Inventory ground samples from the Forest District sorted list.
2. Select the 10 polygons for the WPV and the 16 NVAF sample points from the list of provincial inventory ground samples.
3. Stratify the District to determine the provincial inventory ground samples that meet management inventory objectives. Subtract this number of samples from the total required for each management inventory. Select the remaining number of management inventory samples.

4. Prepare a field sampling plan that includes sample cluster batches to ensure an unbiased sample is attained at the end of the first field season. Identify NVAF sample points and ensure they are field sampled early in the field season.
5. Locate and measure ground samples.
6. Monitor quality assurance of field data and procedures during field sampling. Arrange for 'audit quality cruisers' to sample auxiliary plots of NVAF samples.
7. Prepare NVAF tree sampling matrix. Begin NVAF destructive sampling.
8. Compile the data as it is collected. This will include computing averages of timber volume, basal area, and regression of photo estimated volume to ground sample volume, and the associated standard error of the regression. Calculate the CV and determine the exact number of samples required in the second season.
9. Prepare the remaining samples.
10. Locate and measure remaining ground samples in the second field season. Complete stem analysis of the NVAF sample trees. Complete the WPV sampling.
11. Compile all data, and perform any necessary statistical analysis.

The project can be completed in just one year. The only difference would be no recalculation of the CV before the second year.

A VPIP for the ground sampling should be developed following the guidelines outlined in the MOF document *Vegetation Resources Inventory Guidelines for Preparing a Project Implementation Plan for Ground Sampling*.

4.4 Management Inventories

4.4.1 Overview

Management inventories produce spatial or non-spatial data to address one or more resource-specific management issues (timber supply analysis, ecosystem, and habitat management). They can also be used to increase the precision of the provincial VRI. Management inventories involve ground-sampling activities, with sample locations being selected from existing or new photo-interpreted data sources. The inventory units (sub-units) for management inventories vary and are defined based on business needs.

Management inventories are the responsibility of the stakeholders. A management inventory VPIP, which includes a sampling plan, must be prepared for MOF approval.

One sub-unit was identified in the Columbia Forest District. The ground sampling objectives are listed below:

- *Rare Plant Species*: to conduct a rare plant species inventory and improve the biodiversity assessment (i.e., plant lists) in the District.

4.4.2 Sampling Plans

Supplemental sampling will be required to achieve the management inventory objectives. No requirements have yet been defined for the Rare Plant Species Management Inventory. The VPIP will define the population to be sampled as well as the number of samples to be installed.

4.4.3 Implementation

It is recommended that the stakeholders should have another meeting before implementing any management unit inventory work. The stakeholders will assist in the development of the ground sampling VPIP. The VPIP should be developed following current MOF guidelines.

5. IMPLEMENTATION STRATEGY

5.1 Priorities

At this time it is not possible to assign priorities to the inventory activities outlined in this plan. Priorities will be established at a later time as funding sources become more clear.

5.2 Scheduling

The ground samples that are established to meet the management inventory objectives can also meet the provincial VRI objectives, provided that these multi-purpose plots are identified in advance. Therefore, provincial VRI plots will be identified prior to identifying the management inventory ground plots. Some of these coincident plots will be used for both the provincial VRI and the management inventory. Additional management inventory samples will be established to meet management inventory objectives. This integrated approach, using one set of samples to address multiple inventory needs, will result in minimum implementation costs.

5.3 Costs

Estimated costs for the ground sampling inventory activities proposed in this VSIP are given in Table 5. The retrofit of the Revelstoke TSA and the new photo interpretation in the National Parks will cost approximately $1.00/ha.

Table 5. Estimated costs for the provincial VRI ground sampling in the Columbia Forest District

VRI Tool	No. Samples	Est. Cost/Sample	Total
Full Measure VRI Plots	130	$1,700	$221,000
Timber Emphasis VRI Plots	60	$1,000	$60,000
NVAF (trees)	85	$600	$51,000
WPV	10	$3,000	$30,000
Quality assurance (10% field costs)			$36,000
Statistical analysis			$5,000
Total			*$403,000*

5.4 Monitoring

The Ministry of Forests, Resources Inventory Branch is responsible for monitoring this VRI Strategic Inventory Plan.

5.5 Next Steps

It is recommended that the stakeholders have another meeting before implementing any VRI inventory work. The scheduling of this meeting will depend on the availability of funds to proceed with any VRI projects.

6. APPROVAL/SIGNING

I have read and concur with the Columbia Forest District VRI Strategic Inventory Plan, dated March 3, 1999. It is understood that this is an agreement-in-principle and does not commit the signatories to completing the inventory activities outlined within the plan. Modifications to this plan or more detailed plans need to be reviewed and approved by the signatories.

_____

District Manager
Columbia Forest District

_____

Regional Manager
Nelson Forest Region

_____

Director
Resources Inventory Branch

Appendix A – Glossary of Terms

Ground Sampling

Ground sampling is the field measurement of timber, ecology, range, and/or coarse woody debris values at one or more locations within each sample polygon. The sample polygons are selected proportional to their area from a sorted list. To accommodate the wide variety of resources, various types and sizes of sampling units (e.g., fixed and variable plots, transects) are used to make the measurements.

Inventory Unit

An inventory unit is the target population from which the samples are chosen. For the provincial VRI, the inventory unit is the Forest District, which includes the timber harvesting landbase, parks, recreational areas, private, and federal lands. For management inventories, the inventory unit is a subset of the provincial VRI inventory unit that focuses on a geographic area or specific attribute set, depending upon the sampling objectives.

Landcover Classification

The BC Landcover Classification Scheme (BCLCS) was designed specifically to meet the requirements of the VRI, in addition to providing general information useful for "global vegetation accounting" and "integrated resource management." The BCLCS is hierarchical and reflects the current state of the landcover (e.g., presence or absence of vegetation, type and density of vegetation) and such fixed characteristics as landscape position (i.e., wetland, upland, alpine). There are two main classes of polygons: Vegetated and Non-Vegetated.

Management VRI

Management VRI are specialized inventories that provide more detailed information required for specific resource management, i.e., day-to-day forest management. One or more VRI sampling procedures may be used for management inventories. Management inventories may focus on specific resource types (timber, range, ecology), geographic areas (e.g., landscape unit, TFL), attribute sets (e.g., Douglas-fir leading stands, age class 4+). They may use one or more of the following tools (e.g., photo-interpreted estimates, ground sampling, NVAF sampling).

National Forest Inventory (NFI)

The NFI provides information on Canada's resources across all provinces and allows the Federal Government a consistent framework for reporting on Canada's inventory. The inventory unit for the NFI is the entire country, although it is implemented province-by-province.

Net Volume Adjustment Factor (NVAF) Sampling

NVAF sampling provides factors to adjust net tree volume, which is estimated from net factoring and taper equations. The adjustment accounts for hidden decay and possible taper equation bias. NVAF sampling involves detailed stem analysis of sample trees, calculation of actual net volume, and calculation of the ratio between actual net volume and estimated net volume.

Photo-Interpreted Estimates

Photo-interpreted estimates inventory involves the subjective delineation of polygons and the photo estimation of attributes for all polygons in an inventory unit. Medium scale aerial photographs (1:15,000) are most often used in the photo-interpreted estimates inventory. However, if the existing photo-based inventory is acceptable, the database can be translated into VRI format and upgraded to include the additional VRI attributes.

Post-Stratification

Post-stratification involves the division of an inventory unit into mutually exclusive sub-populations (strata) *after* ground sampling has been completed. Samples that fall in each post-stratum are analyzed separately and the results are applied to the corresponding population post-strata to improve the precision of the inventory's overall averages and totals.

Pre-Stratification

Pre-stratification involves the division of an inventory unit into mutually exclusive sub-populations (strata) *before* ground sampling to provide estimates for specific areas, or to increase the confidence in the overall estimates by considering the special characteristics of each stratum.

Provincial VRI

The provincial VRI provides baseline data for provincial inventory reporting, monitoring, and research. All of the sampling procedures from the VRI toolbox are used for this inventory at the Forest District level. The databases generated from each District

inventory will be compiled to create the provincial VRI database. The provincial VRI has also been referred to in the past as the District VRI.

Resource-Specific Interpretations

Resource-Specific Interpretations (RSI) use the RIC standard VRI baseline data products (provincial VRI or management inventory), in combination with other data sets and analysis (outside of that required to produce VRI), to produce information to address specific-resource management issues (e.g., TSR review, important ecosystems, important habitats). These interpretations include ecosystem interpretations and habitat interpretations.

Retrofit

Retrofitting is the process of translating and upgrading an existing photo-based inventory to VRI standards. If the polygon linework and attributes are of acceptable quality, the existing FIP (Forest Inventory Planning) databases are translated to VIF (Vegetation Inventory Files) databases and the additional attributes required by the VRI are re-estimated from the aerial photographs.

Sample Size

The sample size for an inventory is the minimum number of ground samples to be established in an inventory unit to meet the target precision.

Statistical Analysis

Statistical analysis is the process of adjusting the values of the photo-interpreted estimates variables using the ground sampling observations. For each sampled polygon, the ground observations are compared to the photo-estimated values to develop an adjustment factor. This factor is then applied to all polygons in the photo-interpreted estimates database to produce the final adjusted database.

Sub-unit

The term sub-unit describes the inventory unit of a management inventory (i.e., the management inventory target population is a subset of the provincial VRI inventory unit). A sub-unit may be defined by a specific geographic area (e.g., operable landbase) or stand type (e.g., problem forest types) within the Forest District.

Target Precision

Target precision expresses the amount of variation in key attributes (e.g., timber volume) desired in the final results. The target precision, usually expressed as the coefficient of

variation (CV), is used to calculate the minimum sample size for subsequent ground sampling.

Vegetation Resources Inventory (VRI)

The VRI is an improved vegetation inventory process for assessing the quantity and quality of BC's vegetation resources. The VRI process is designed to include a flexible set of sampling procedures for collecting vegetation resource information. The VRI is essentially a toolbox of procedures, which include:

- *Photo-interpreted estimates*: the delineation of polygons from aerial photography and the estimation of resource attributes.
- *Ground sampling*: the establishment of plot clusters in selected polygons to measure timber, ecological, and/or range attributes.
- *NVAF Sampling*: Stem analysis sampling of individual trees for net volume adjustment.
- *WPV Sampling*: Intensive sampling of selected polygons to determine the error between the estimated attribute values and the "true" attribute values.
- *Statistical Adjustment*: the adjustment of the photo-interpreted estimates for all polygons in an inventory unit or management unit using the values measured during ground sampling.

The VRI can be deployed over the entire province (provincial VRI) measuring timber and non-timber resources, or over a large management unit (management VRI) measuring selected resources in specific portions of the landbase. The VRI sampling process produces spatial and non-spatial databases that can be used in multiple resource management applications including timber, ecosystem, and wildlife habitat management.

Within Polygon Variation (WPV) Sampling

WPV sampling provides information for expressing the true individual polygon error, assessed as the difference between the adjusted polygon value and the "true" value for that polygon. The "true" value for the polygon is an estimate derived from a small sample of polygons that are intensively sampled on the ground.

Appendix B – VRI & Post VRI Components, Steps, Roles, and Responsibilities

The VRI is undertaken in the context of business needs, and the need for baseline vegetation inventory data. VRI and post-VRI information is developed to address issues identified in the planning processes. Many components are involved: 1) developing VRI baseline data products (as defined by RIC standards), and 2) developing VRI-based information products (e.g., maps for timber, ecosystems, habitat, etc.) to address the issues (as defined by RIC or Ministry standards).

The objective of this Appendix is to provide an overview and identification of all the components, their sequence, and tentative participant roles for both VRI and post-VRI information development.[8]

These components include:

VRI

a) Development of procedures and standards to undertake the VRI
b) VRI strategic planning
c) VRI District operational planning
d) Implementation of provincial VRI, district-wide
e) Implementation of management VRI, sub-district

Post-VRI

f) Implementation of management inventories
g) Ecosystem and habitat mapping (information development)
h) Land integration planning

Each of these components, and the responsible and participating/supporting agencies, are summarized in Table 8. Note that the responsible and participating/supporting agencies will vary among Regions and among projects, depending on funding scenarios and workloads of the various agencies.

[8] The first draft of this is Appendix was prepared by Ron Kot, MELP.

Table 6. Overview of VRI components, steps, and example of roles and responsibilities.

Inventory Component	Responsible Agency	Participating/ Supporting Agencies
VRI		
A. Production of VRI Procedures and Standards		
1) Photo interpretation	MOF	MELP
2) Ground sampling	MOF	MELP
3) Quality Assurance	MOF	MELP
4) Net Volume Adjustment factor (NVAF) sampling	MOF	
5) Within Polygon Variation (WPV) sampling	MOF	
6) Data and warehouse standards and quality control procedures	MOF	
7) VRI Change Management Process	MOF	
B. VRI District-level Strategic Planning		
Development of VSIP	MOF (RIB) leads	Stakeholders: Industry, MOF, MELP, other agencies,
C. VRI Operational Planning		
1) Development of VPIPs	MOF (District) approves, industry/proponent (could be MOF) prepares	Stakeholders: Industry, MOF, MELP, other agencies
2) Funding Responsibility & Lead Proponent		
- TFLs	Licensee	
- TSA	MOF	
3) Submission to FRBC or other funding agency.	Lead Proponent	MOF, other stakeholders
D. "Provincial VRI" District-wide Inventories		
1) VRI Implementation	MOF (Region)	
2) VRI Data Warehouse (Data products "Custodianship")	MOF (RIB)	
E. "Management VRI" Sub-district Inventories		
1) VRI Inventory Implementation		
-TFLs	Licensee	
-TSAs	MOF	MELP and other agencies?
2) VRI Data Warehouse (Data products "Custodianship")	MOF/Licensee Is this VRI at this stage? All products to MOF RIB data warehouse?	

Inventory Component	Responsible Agency	Participating/ Supporting Agencies
POST - VRI		
F. Resource-specific Information Development		
1) Timber Information Development	MOF/Licensee (TFL)	
a) methods and standards	MOF	
b) Inventory needs id and planning – Strategic	id in VRI Plan	
c) Inventory needs id and planning – Operational	id in VRI Plan	
d) funding / funding submission		
e) Undertake Inventory		
- TFL	Licensee	
- TSA	MOF	
f) warehousing products ("Custodianship")	Licensee/(MOF)?	
2) Ecosystem and Habitat Mapping and Information Development		
a) Methods and Standards	MELP steward	
b) Inventory needs id and planning – Strategic	id in VRI Plan	
c) Inventory needs id and planning – Operational	id in VRI Plan	
d) funding submission (100% FRBC fundable)	Proponent: Licensee?	
- TFL	MELP?	
- TSA		
e) Undertake Inventory		
-TFLs	Licensee	MELP
-TSAs	MELP	MOF
f) Warehousing products ("Custodianship")	MELP custodian	
G. Land Integration Planning		
Management strategies and prescriptions	Licensee/MOF	MELP

Appendix C – Meetings and Conference Calls

September 18, 1997: Initial VRI Meeting Held at the Revelstoke Forest Service Office.

Attendees:	John Cruickshank, Ken Gibson:	Columbia Forest District
	Chris Mulvihill, Cal Hauk:	Nelson Forest Region
	Mark Gillis, Ken Richardson:	Resources Inventory Branch
	Susan Hall, Murray Peterson:	Parks Canada
	Del Williams:	Revelstoke Community Forest Corp.
	Bob Holland:	Evans Forest Products
	A.Y. Omule, Fei Disbrow:	JS Thrower & Associates

November 7, 1997: Verbal Sign-off Conference Call

Attendees:	John Cruickshank, Ken Gibson:	Columbia Forest District
	Chris Mulvihill, Cal Hauk:	Nelson Forest Region
	Mark Gillis, Ken Richardson, Sam Otukol, Gary Johansen:	Resources Inventory Branch
	Susan Hall, Murray Peterson:	Parks Canada
	Del Williams:	Revelstoke Community Forest Corp.
	A.Y. Omule, Fei Disbrow:	JS Thrower & Associates

November 21, 1997: Ecological Information Conference Call

Attendees:	John Cruickshank, Ken Gibson:	Columbia Forest District
	Tom Braumandl:	Nelson Forest Region
	Bob Brade:	MELP Columbia Forest District
	A.Y. Omule, Fei Disbrow:	JS Thrower & Associates

February 24, 1999: VRI Meeting Held at the Revelstoke Forest Service Office to Redefine Inventory Issues and Activities

Attendees:	John Cruickshank:	Columbia Forest District
	Chris Mulvihill:	Nelson Forest Region
	Susan Hall, Murray Peterson:	Parks Canada
	Del Williams, Bob Clarke:	Revelstoke Community Forest Corp.
	Bob Holland:	Evans Forest Products